Assigned on April 6th 2020 at 10:30 am-Due on April 7th 2020 at 12:30 pm

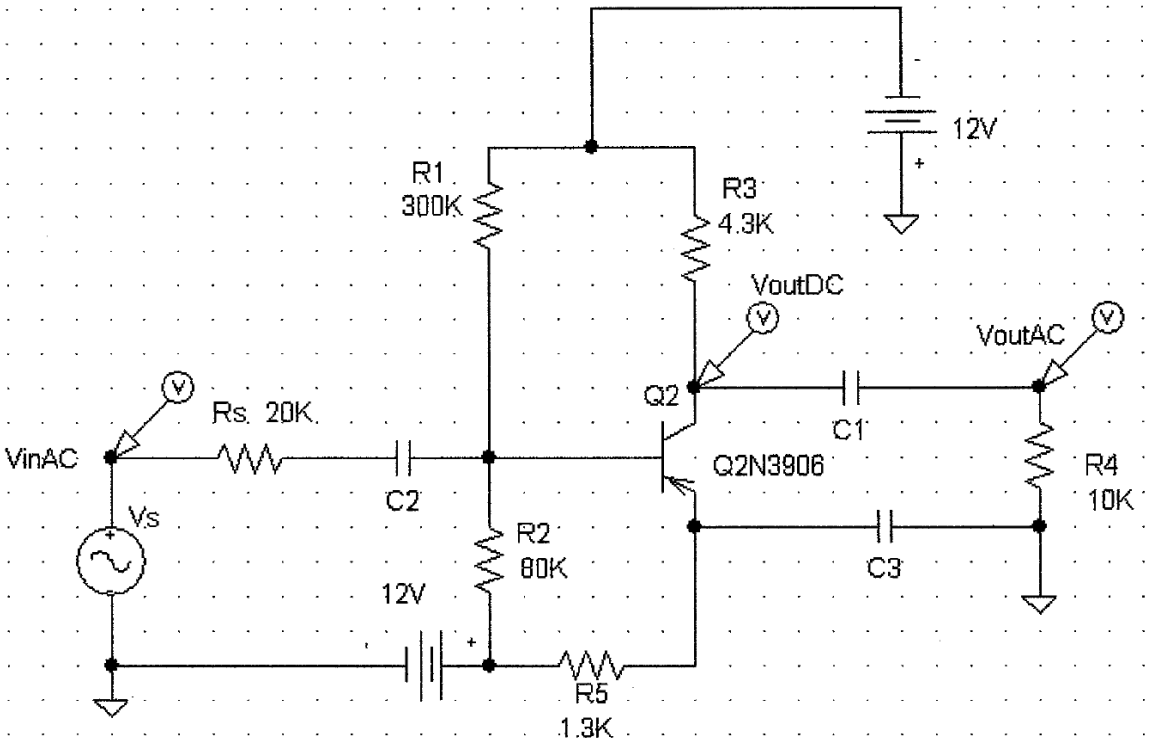
NAME: David Kirby **MAXIMUM POINTS: 100+15 Extra-credit**

ECE 322L: Electronics-II (Spring 2020, University of New Mexico)

MID TERM EXAMINATION-II

Problem 1 (100 pts.)

For the circuit below: $V_{EB(on)}$=0.7 V, β=180.7, V_A=100 V, V_{inAC} = 1 mV amplitude (i.e., 2m V peak to



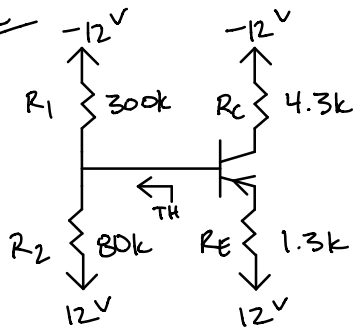
peak sinusoidal signal) at 1 KHz.

Given the above input voltage, V_{inAC}, sketch (or plot) and accurately label a plot the TWO output waveforms V_{outAC} and V_{outDC} on the graph paper provided on the next page. Assume the turn on voltages for all forward biased junctions are 0.7 V. You may assume all capacitors are AC shorts. For full credit, be sure to check your assumptions on the mode of operation of the transistor and to clearly label the axes of your plot.

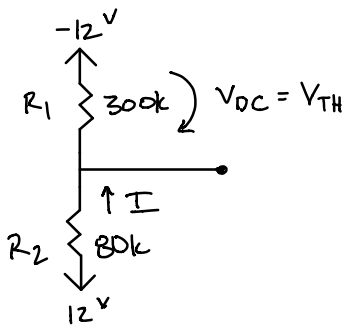
Extra-credit question (15 pts.)

Identify the corresponding different operation regions of a pnp BJT in each quadrant of the V_{EB}-V_{CB} parameter space.

DC



Thevenin



$V_{TH} = -12^V + IR_1$ $\qquad I = \frac{12-(-12)}{R_1+R_2} = \frac{24^V}{380k\Omega} = 63.158\mu A$

$= -12^V + (63.158\mu A)(300k)$

$= 6.9474^V$

$R_{TH} = R_1 // R_2 = 300k // 80k = 63.158k\Omega$

KVL

$V^+ = (1+\beta) I_{BQ} R_E + V_{EB(on)} + I_{BQ} R_{TH} + V_{TH}$

$12^V = (181.7) I_{BQ} (1.3^{k\Omega}) + 0.7^V + I_{BQ} (63.158^{k\Omega}) + 6.9474^V$

$I_{BQ} = 14.539\ \mu A$

$I_{CQ} = \beta I_{BQ} = (80.7)(14.539\mu A) = 2.6273\ mA$

$I_{EQ} = \frac{I_C(1+\beta)}{\beta} = 14.620\ \mu A$

Check Assumptions

$V_{EB} \geq V_{EB(on)} = 0.7^V$

$V_{CB} < V_{CB(on)} \simeq 0.4^V - 0.5^V$ (typical values)

$V_C = V^- + I_C R_C = -12 + (2.6273\ mA)(4.3k) =$ **-0.7027^V** (Vout DC)

$V_B = V_{TH} + I_B R_B = 6.9474^V + (14.539\ \mu A)(63.158k\Omega) = 7.866^V$

$V_E = V^+ - I_E R_E = 12^V - (14.620^{\mu A})(1.3^{k\Omega}) = 11.981^V$

$V_{CB} = V_C - V_B = -0.7027^V - 7.866^V = -8.5684^V$

$V_{EB} = V_E - V_B = 4.1153^V$

$V_{EB} \geq V_{EB(on)} = 0.7^V$

$4.1153 \geq 0.7$ ✓

$V_{CB} < V_{CB(on)} \simeq 0.4^V - 0.5^V$

$-8.5684 < 0.4$ ✓

The assumption of for. active mode is verified.

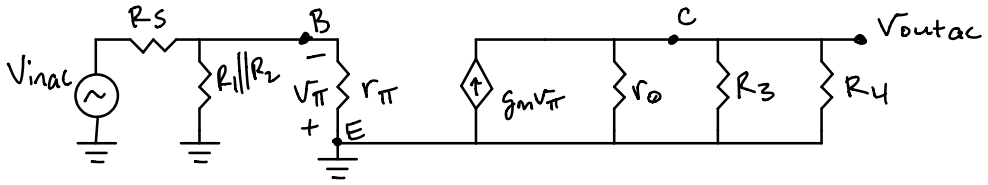
$V_{EC} = V_E - V_C = 11.981^V - (-0.727^V) = 12.684^V$

AC

$$g_m = \frac{I_c}{V_T} = \frac{2.6273mA}{0.0259^V} = 0.10144 \frac{A}{V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{180.7}{0.10144} = 1.7814k\Omega$$

$$r_o = \frac{|V_A|}{I_C} = \frac{100^V}{2.6273mA} = 38.062k\Omega$$



$$G_V = \frac{V_{outac}}{V_{in\,ac}} = \frac{V_{outac}}{V_\pi} \cdot \frac{V_\pi}{V_{in}}$$

$$V_\pi = V_{in}\left(\frac{r_\pi || R_1 || R_2}{R_s + r_\pi || R_1 || R_2}\right)$$

$$= (1mV)\left(\frac{1.7814k\Omega || 80k || 300k}{20k + 1.7814k || 80k || 300k}\right)$$

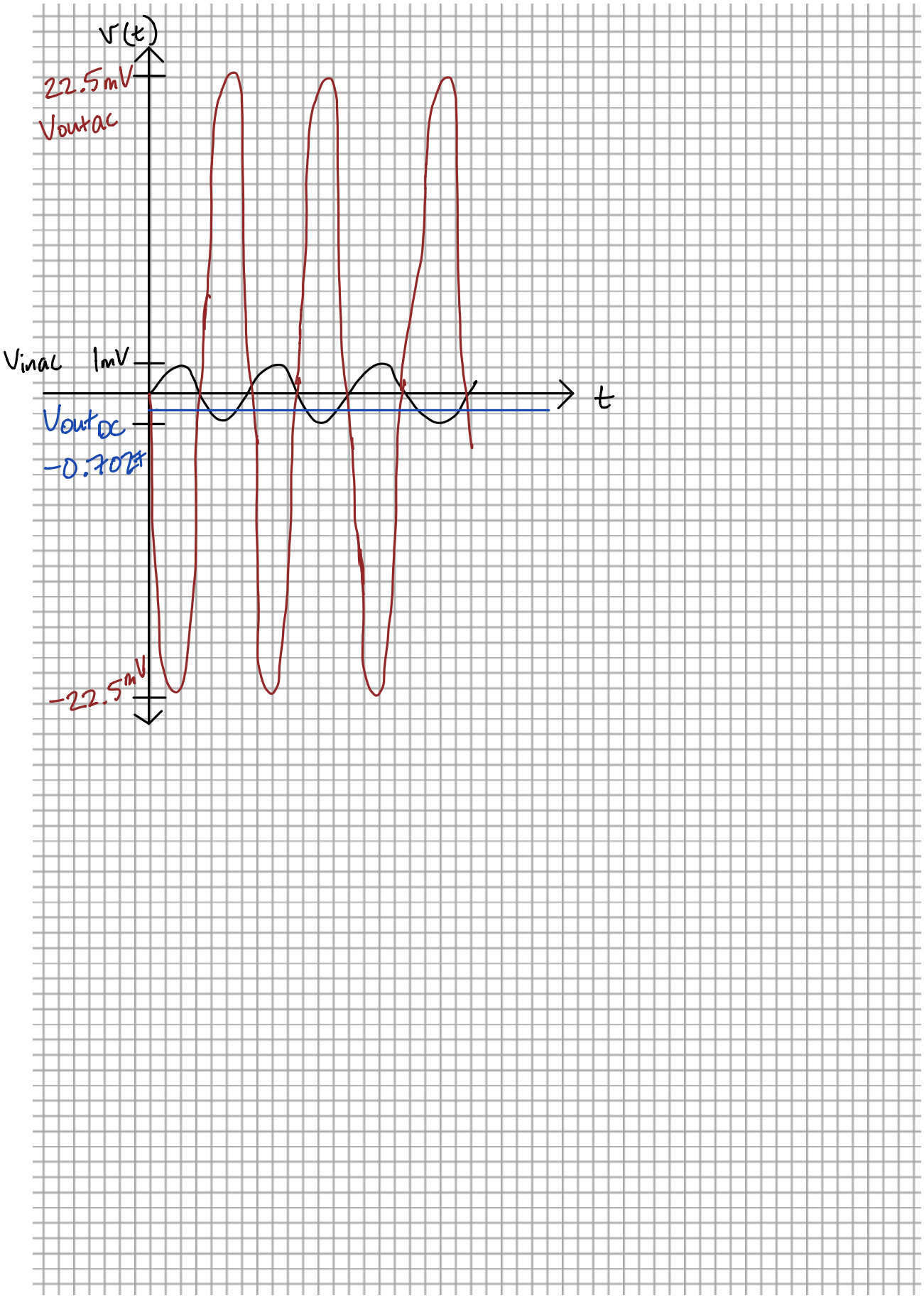
$$= \left(1mV\right)\frac{1.7325k\Omega}{21.733k\Omega} = 79.719mV$$

$$V_{outac} = -g_m V_\pi (r_o || R_3 || R_4)$$

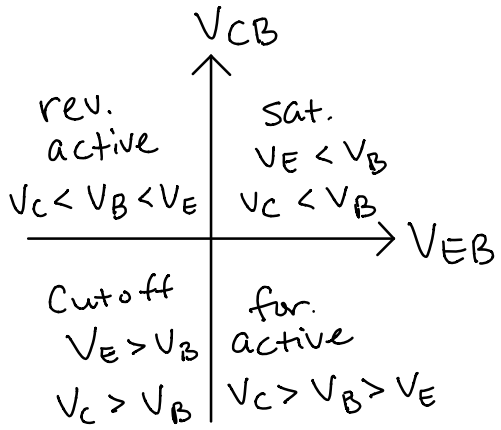
$$= (-0.10144)(79.719m)(2.7868k)$$

$$= -22.536$$

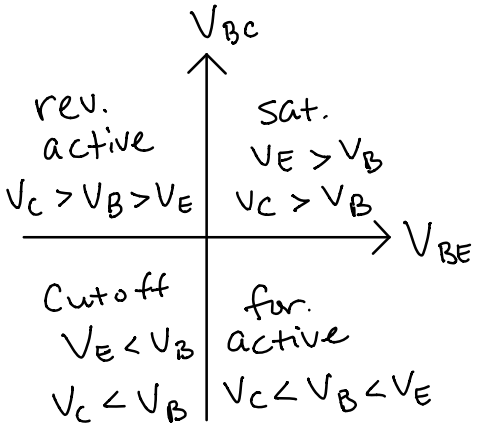
$$G_V = \frac{V_{outac}}{V_{in\,ac}} = -22.536$$


V(t)
22.5mV
Voutac
Vinac
1mV
t
Voutdc
-0.707
-22.5mV

Extra Credit



For pnp we use the graph from class, but replace V_{BC} with V_{CB} and replace V_{BE} with V_{EB}.



Alternatively, we could flip all of the signs.